

Date of issue.	♂	♀
8th October, 1903 ...	2	1
10th        "       " ...	1	2
16th        "       " ...	...	1
Total	16	16 = 32 moths.

In addition to these 32 moths there were two others which never acquired their proper wings on issuing, probably due to the handling the chrysalids received. It is probable that at least 40 moths left this tree during September and October.

In addition to the small *Cassia nodosa* tree, which may be said to have been killed by this insect during the present year, a much larger tree some 35 feet high and three feet in girth has been attacked, more especially at its base, as evidenced by several empty pupal cases protruding from the bark surface.

The moth was noticed in various parts of Calcutta during the above-mentioned weeks, and was evidently this year fairly abundant. We have yet to discover what other trees it infests in addition to the *Cassia nodosa* which Major Prain, who very kindly identified the tree for me, tells me was originally sent to the Museum from the Royal Botanic Gardens at Sibpur.

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*The Cyclone in the Bay of Bengal, between the 13th and 15th November, 1903.*—By C. LITTLE, Esq.

With four plates.

[Read 2nd March, 1904.]<sup>1</sup>

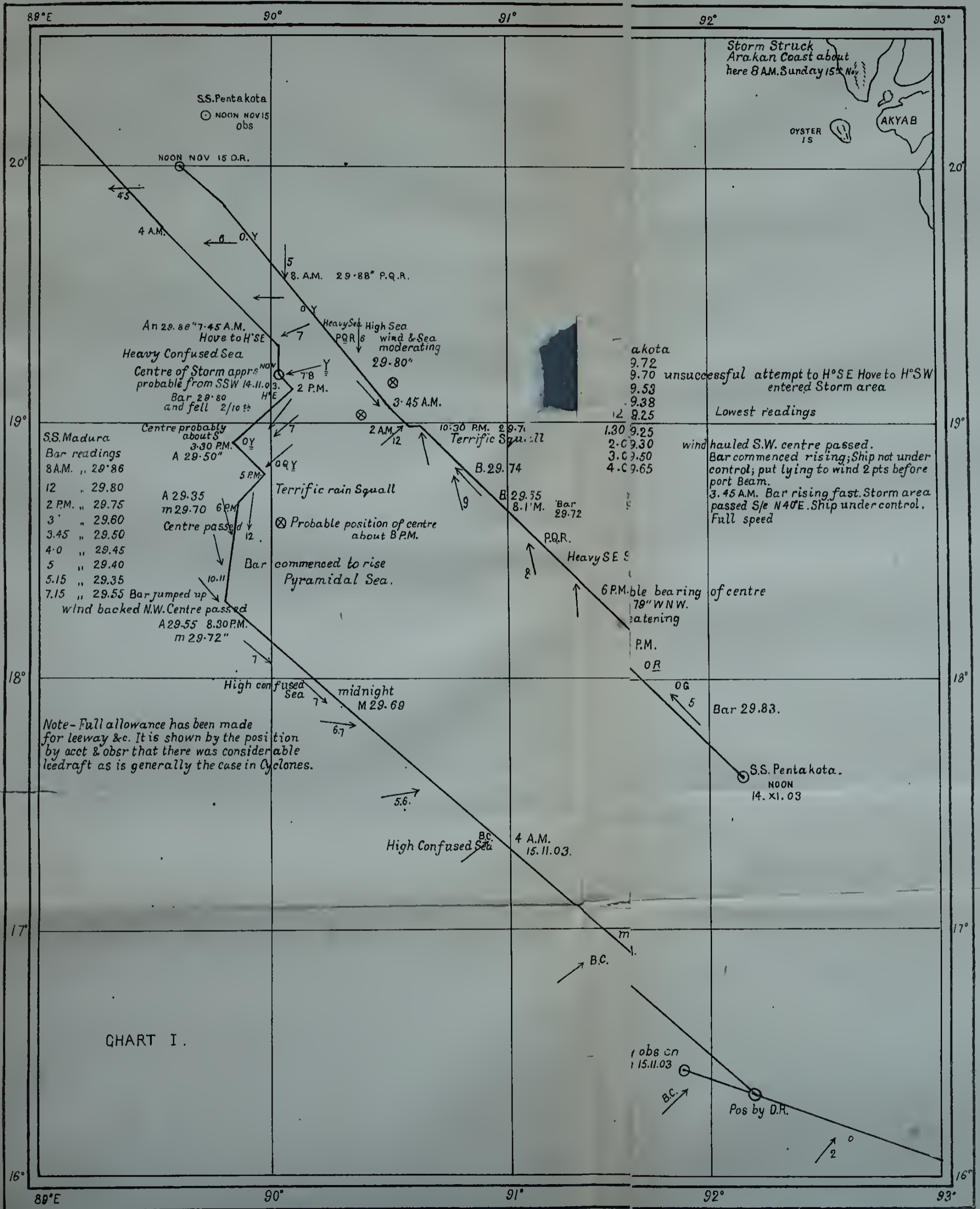
In the early days of meteorological study in India, a first place was naturally given to the cyclone, and numerous discussions of more or less remarkable examples of cyclonic storms are on record. Piddington, Blanford, Wilson, Pedler, and last but not least, Sir J. Eliot have added to that record, of which a summary may be found in the Handbook of cyclonic storms by the last-named. A reference to the original memoirs will show that the investigators, at all events the later ones, overlooked not the smallest details, with the result that these details almost appear to be the main object of the discussion. But that had carried with it its own cure. Now it is recognised that many

<sup>1</sup> Publication delayed by proofs having to be sent to England.

Course of the B.I. Steamer "Madura" in the C<sub>1</sub> of November 14<sup>th</sup> 1903.

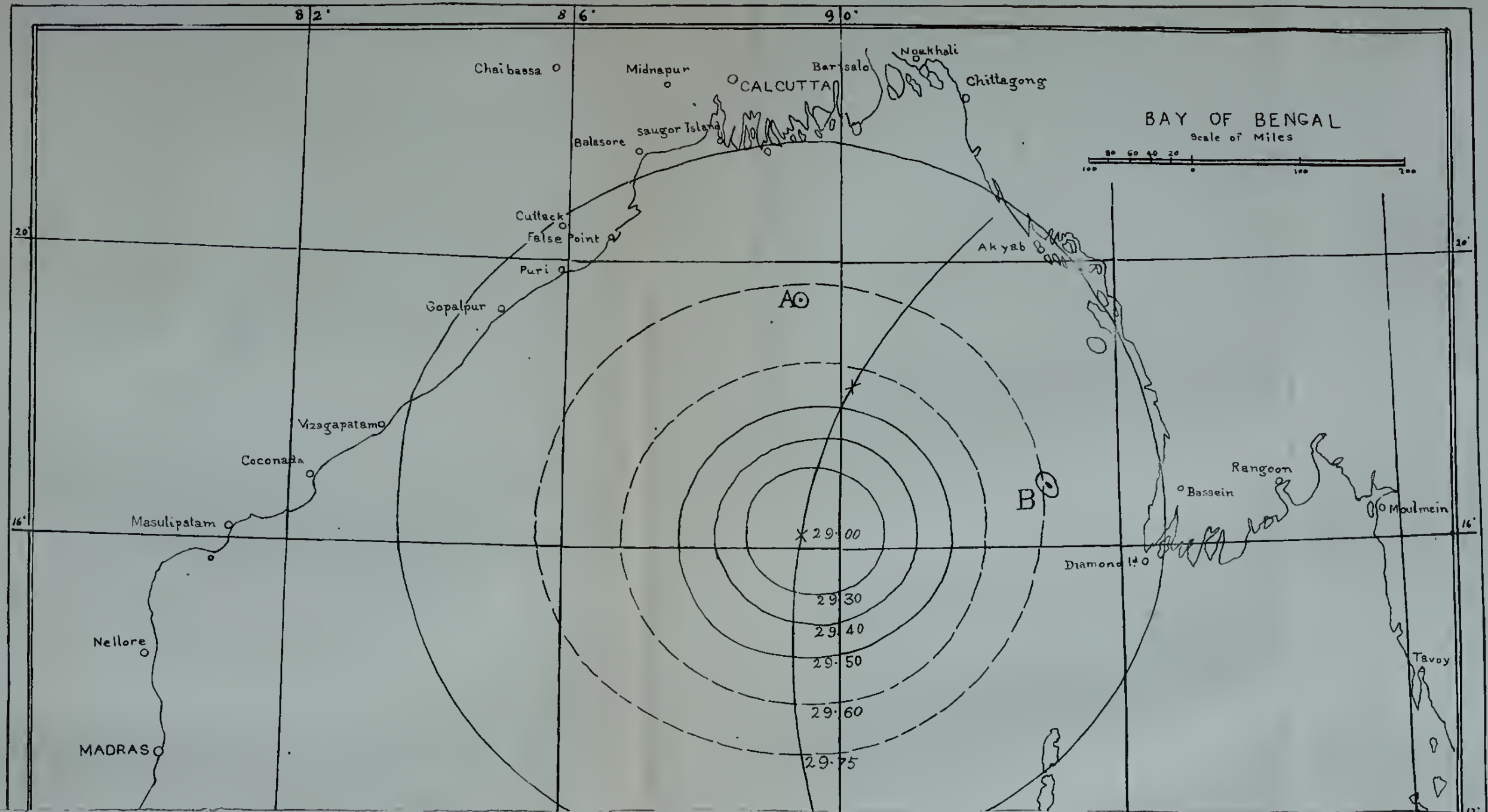
Little Journ. As. Soc. Beng. 1904. Vol. LXXIII.

Plate II.









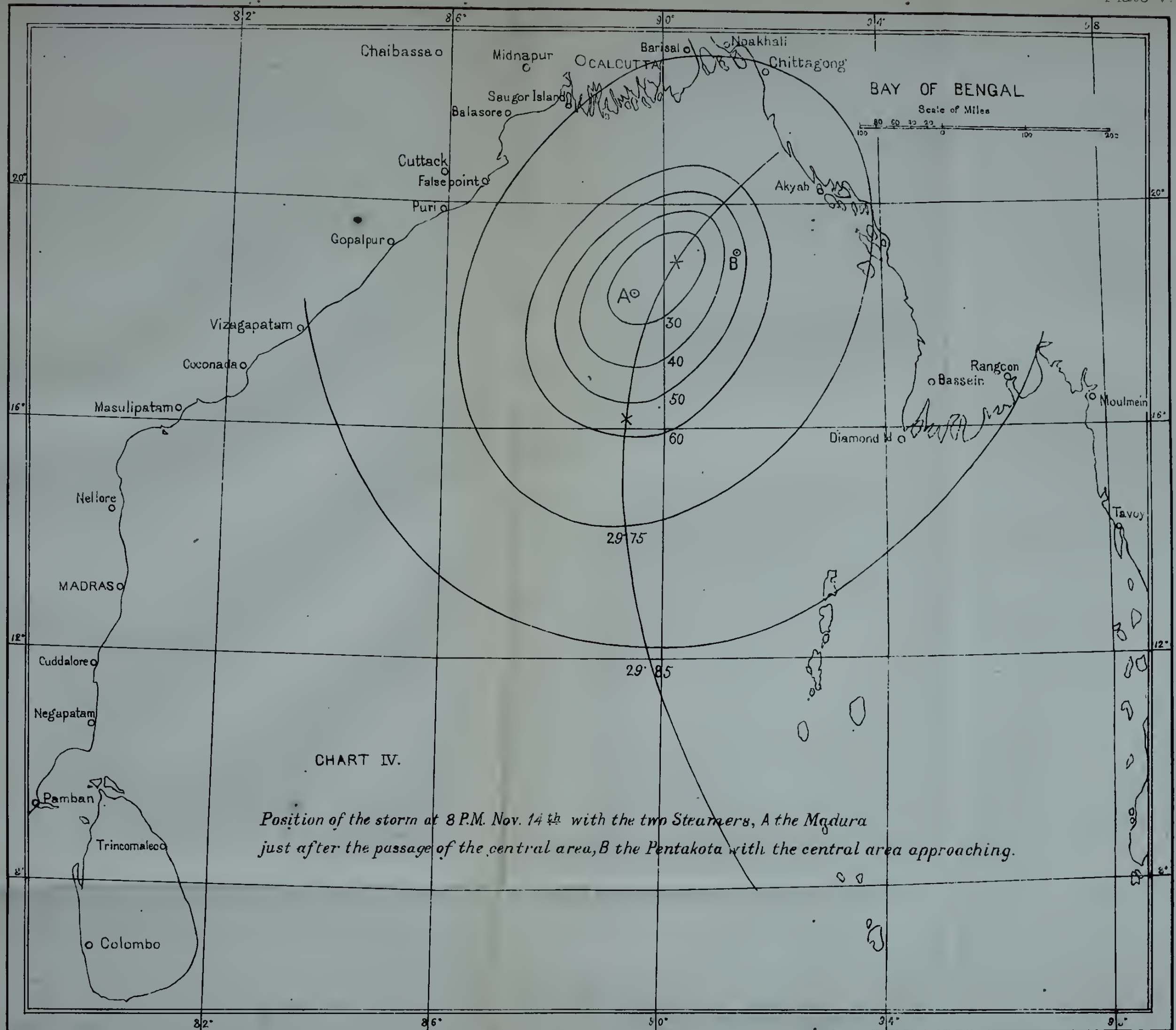
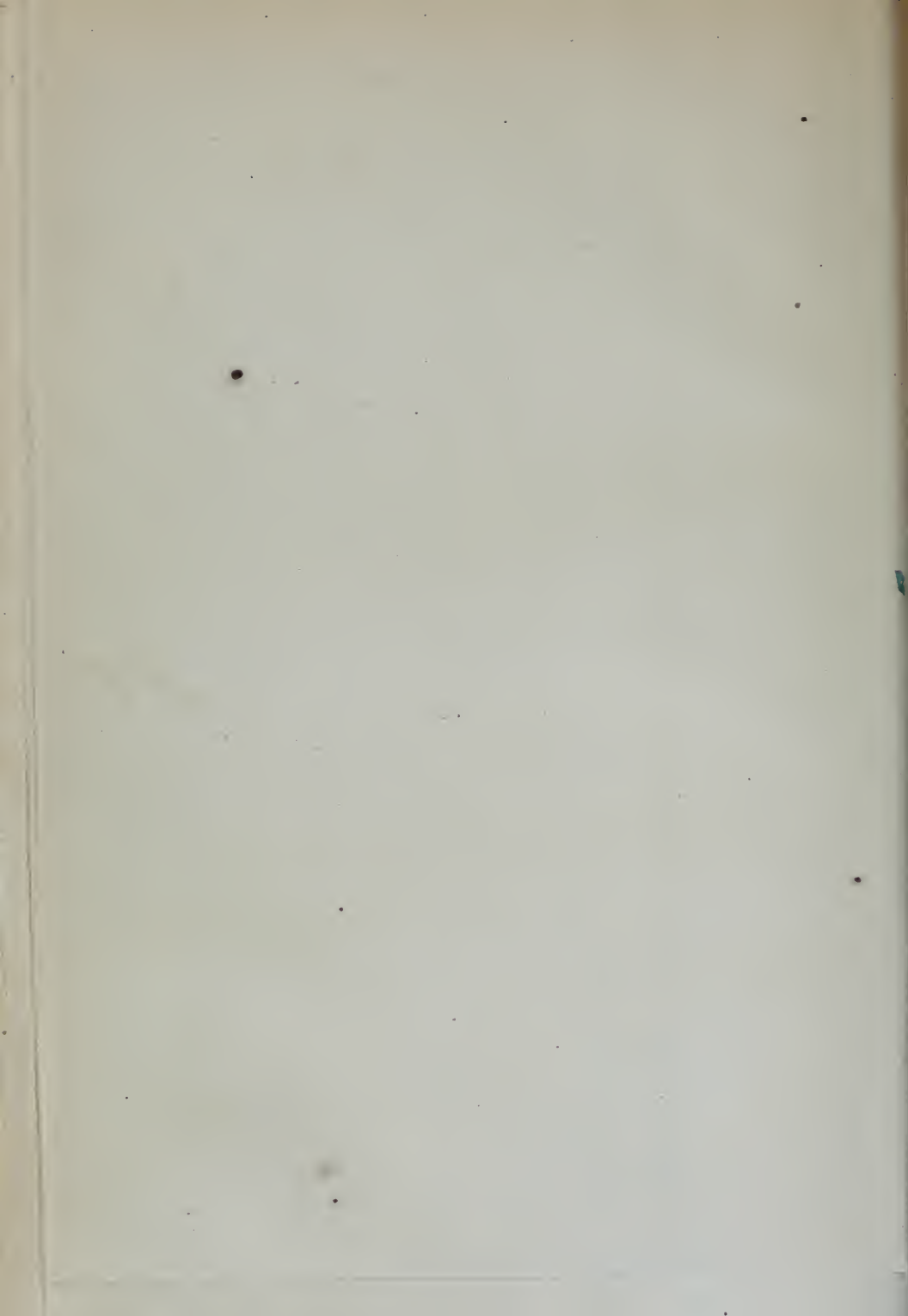


CHART IV.

*Position of the storm at 8 P.M. Nov. 14<sup>th</sup> with the two Steamers, A the Madura just after the passage of the central area, B the Pentakota with the central area approaching.*



of the details are unimportant in their bearing on the grand central problem of the cyclone. As a consequence, a cyclonic storm such as that of the 14th November last, receives less voluminous attention now than it would have done fifteen or twenty years ago.

I have a two-fold purpose in offering this brief paper for publication :—

- (1) To show by means of the experiences of the Steamers *Madura* and *Pentakota*, one from Calcutta to Rangoon, the other from Rangoon to Calcutta, how difficult it is to avoid the dangerous central area of cyclones by a study and application of the rules given in Sir J. Eliot's Handbook, even supplemented by such local observation as is possible in stormy weather.
- (2) To point out that the peculiarity called "recurving," present in all severe cyclones, has never been investigated or explained, and that until more is known regarding that part of the cyclonic phenomenon, rules may enable seamen to evade imaginary cyclones where no danger exists, but will be of little avail in dangerous storms.

In the introduction to the Second Edition of the Handbook of Cyclonic Storms, Sir J. Eliot says :—

"By following these or similar instructions he (the mariner) will, in the great majority of cases, if not in all, when he is involved in cyclonic weather in the Bay of Bengal, be enabled to avoid the inner storm area of dangerous winds, and fierce squalls and rapid shifts of wind."

"I may here point out that my aim throughout the book has not been to give hard and fast rules, the observance of which will enable any seaman to pursue the safest course when he meets with a cyclonic storm in the Bay of Bengal. I do not believe it is possible to draw up rules which will be of use without the co-operation of the full intelligence of the person who wishes to employ the experience embodied in any series of rules drawn up for his guidance."

As I understand the above remarks, the difficulty is not considered to be as regards the reliability of the rules, but as regards the "full intelligence of the person." Now, in my opinion, and it is based on fifteen years' experience not only of telegraphed reports but of personal observation, rules are quite useless in the case of a storm such as that of the 14th November, and will continue to be useless until one is added enabling the sailor to estimate the amount of recurving. Until then the intelligence of the sailor cannot be implicated.



When I use the expression personal observation, I do not wish it to be understood that that part of my experience was gained at sea. I refer to storms which have recurred over Lower Bengal. In all cases, whether at sea or on land, I have seen no reliable indication supplied by the telegraphed reports, on which could be based any statement beforehand that the storm will recur. But that recurring is readily shown afterwards by ground-level observations. Now, because the recurring is so readily shown, and because the result of it may be that ships or ports, to all appearance free from danger, become involved in the storm, the onus of proving that this occurrence could not be foreseen may at any time fall upon some individual ill-prepared to meet the charge. It, therefore, appears to me to be important that it should be fully recognised that, as far as present-day knowledge of storms goes, recurring can be neither foreseen nor provided against. In support of this belief I put forward the cyclonic storm of November 14th last, and the tracks of the two steamers. This is not, it should be understood, the only storm in the period over which my experience extends, that might be brought forward as evidence in favour of my contention. But a rapidly-moving cyclone, such as the one of the 14th November, last was, with the accident of two ships moving from opposite directions on the outer boundary of the storm at noon and involved in the hurricane area before midnight, gives a very rare combination—so rare that full advantage should be taken of the lessons to be extracted. It will be seen that both ships, under entirely different circumstances, continued steering almost directly towards the storm area, and this is more remarkable in the case of the *Madura*, because everything was done that a study of the rules laid down by Sir J. Eliot in the Handbook and “the full co-operation of the intelligence of the person” could do to keep away from the storm centre. It should be remembered that these ships were navigated by men who have had many years’ experience of weather in the north of the Bay, who have made a careful study of the historical survey of the various storms in the Handbook, and have been compelled by circumstances to watch weather changes very carefully. It should also be remembered that besides the Captain of the ship there was on each vessel a member of the Hooghly Pilot Service, whose members are specially acquainted with weather conditions in the north of the Bay. My information was in the first instance received from Mr. Thorpe, of that Service, who was on board the *Madura*; and such facts as have reached me since have all tended to confirm my opinion that the statement of the first page of the Handbook, that in the great majority of cases, if not in all, the mariner will be enabled, by following these instructions, to avoid the storm



area, will not be true until meteorologists have accounted for the part of the phenomenon called "recurving" or "recurvature."

I have attempted to show in other papers that the recurving of depressions over Central and Northern India is associated with important variations in rainfall distribution in India. Its further importance, as a feature of all severe cyclones in the north of the Bay, has, I believe, merely to be recognised to show that this phenomenon of recurving is the most important meteorological problem at present awaiting solution. I consider, therefore, that it cannot be too often repeated that the explanation cannot be supplied by an examination of registers only. It is, in all probability, an effect jointly dependent on changes indicated by the ground level instruments, and on the upper strata of the atmosphere. Should that assumption be correct, its solution must, of a certainty, await observation of the upper strata, and those interested must remain satisfied that no forecast except of the most general kind is possible where recurving is an element to be considered.

The following is an account of the experiences of the S.S. *Madura* on the voyage from Calcutta to Rangoon:—

"Left moorings at 7-0 A.M. 14th, and proceeded down the river, where after an uneventful trip we passed Saugor at 2-0 P.M. The weather signals hoisted there were somewhat nasty, L standing for the part of the Bay we were going to, which means strange winds and probable squally weather, forming apparently part of a cyclonic whirl; but the weather looked so fine that no one was anxious. At 5 P.M. Captain took charge, and we headed away for the Alguada, weather remaining very fine, and with the exception of a slight southerly swell, perfectly calm. Sunset that evening was a sight to behold, being a most magnificent one—clouds soft and woolly in long streaks across the sky, packed close together, being lighted into an extraordinary glow of deep blood-red which lasted for some considerable time. Everyone went to bed early, expecting a pleasant trip, and the weather for the first part of the night remained calm and fine; but towards morning it steadily began to get worse, the wind which had been blowing S.E. and E.S.E. backing round to East till at 4 a strong East breeze was blowing, and a moderate to rough sea was running, and the weather overcast and rainy. 6-0—The wind was still E. but the weather was thickening; at 7-0 the wind and weather much the same; at 7-45 the wind back to E.N.E. with increasing force and heavier sea and a nasty swell from S. It being certain now that a cyclone was approaching, the vessel was hove to, to see what direction the storm was travelling; at 8-0 Bar. 29·86, the wind was still E.N.E., making the storm S.S.W. of us; a strong wind was

blowing and hard squalls with continuous rain. High head sea and heavy swell from S. 10-0—Bar: keeping steady, wind hauled E. x N., but the weather did not improve .11-30—Bar : 29·84, altered course E. x S, storm centre then bearing S.W. x S. from the direction of the wind. 12-0—Wind still E. x N., strong wind and high sea with very heavy squalls, Bar : 29·80. 1-0—Wind back to E.N.E. 2-0—Bar : 29·75, wind N.E. and the weather getting worse, showing storm was crossing our bows. Altered course to S.W. and went full speed. 2-5, wind back N.N.E. and the swell which was very heavy came from S.S.E. 2-25, wind hauled E.N.E. 3-0 Bar : 29·60, wind back for a few minutes to N.N.E. but went round almost at once to E.N.E. 3-25, Bar : 29·50, wind E.N.E. 3-40, wind E, both wind and sea decreasing but heavy swell from S.S.W., which taken with the hauling of the wind and the rapid fall of the Bar. showed storm was setting nearer and crossing our bows, so altered course S.E., having run 18 miles on the previous course: the Bar. now remained steady for a bit but then commenced to fall and the weather to get very much worse. At 4 Bar : 29·45, wind backing again to E.N.E., very strong, with a high confused sea and heavy swell from S.S.W. 5-10, Bar : 29·40, wind again backed to N.E. and weather got worse and worse, showing that storm had probably recurved and was coming towards us. So the course was again altered to S.W. At 5-15 a terrific squall struck the vessel with hurricane force N.N.E., carrying away awnings, after boat and doing damage generally; this kept on with unabated force till 7-15, when the wind which gradually backed from N.N.E. through N to N.N.W. suddenly shifted to N.W., and the Bar: which was pumping badly from 29·35 to 29·40 suddenly jumped up a tenth and a half; from this the weather rapidly improved, the vessel being kept before the wind until at 8-30 with the wind still N.W.; Bar : rising we went on our course again full speed.”

The accompanying charts show more clearly—

- (1) that from 8 A.M. of the 15th, when the centre of the cyclone was about 200 miles distant, until 8 P.M. of the same day when the centre had passed to the north-east of the vessel, the officers were engaged in a continued effort to follow the instructions of the Handbook.
- (2) that the general effect of trying to follow the rules, was not to keep the ship away from the storm area, but to carry her directly towards the approaching centre.
- (3) that the failure to avoid the storm centre was due to the recurving which is so conspicuous a feature of the storm.

It may be said that recurving is so frequently present in cyclones in November that it should have been possible to allow for it on this

occasion. In my opinion recurring is present in all severe cyclones, but it occurs in great variety of degree. Anyone sceptical on this point has only to look at plate XLVII of the Handbook, 2nd edition, and he will find there the tracks of the eight severe cyclones described in the text. The chief feature is that no two are alike, and that not one is like the track of the cyclone of the 14th November.

If it had been possible to estimate on Sir J. Eliot's system of forecasting, that is, by considering changes of pressure and variations from the normal, what the future of the storm would be, it might be expected that it would be shown in the Indian Daily Weather Review for those days. The opinions therein expressed are arrived at on lines laid down by him, and by subordinates directly responsible to him. Reference is made to the numbers from November 13th to 15th, from which the following extracts are made.

*November 13th.*

"The fall of pressure is perhaps most significant at the coast stations round the Bay, as it has been accompanied with a change in the direction of the winds."

"The change in the direction of the winds on the Coromandel and Circars coasts makes it probable that rain will decrease during the day in the south of the Peninsula."

*November 14th.*

"Another general fall of pressure has taken place and the fall has been rapid on the Orissa and North Ganjam coasts.....A depression is forming in the Bay of Bengal and pressure is in considerable to large defect at the stations round the North of the Bay."

"Winds are strong at Diamond Island and are cyclonic in direction round the Bay, though the circulation is not well defined."

"The depression in the Bay will probably intensify during the day. It is apparently advancing in a northerly direction."

*November 15th.*

"The depression in the Bay has advanced in a north-easterly direction, and its lowest point is this morning lying off the Arakan coast near Akyab, where pressure is nearly a quarter of an inch in defect."

"Winds show a cyclonic circulation round the depression in the north-east of the Bay....."

"The depression in the north-east of the Bay will probably cross the coast during the day and fill up rapidly."

The above remarks are all that were made regarding the storm on the dates referred to. They appear to me to show—

- (1) that when the *Madura* was within 200 miles of the centre of a disturbance sufficiently wide-spread to affect the whole of



the northern coast of the Bay, the only indication that could be given on Sir J. Eliot's system was that "a depression has begun to form over the Bay."

- (2) the chief indication given was that the coast most affected at 8 A.M. on the 14th, and therefore the probable objective of the approaching storm was the Orissa and North Ganjam coast. With this may be compared the statement in the report of the *Madura* that at 3-30 P.M. on the 14th the storm had crossed, the bows of the ship then steaming south-west, the course being immediately afterwards changed to south-east.
- (3) that neither from the coast observations at 8 A.M. nor from the observations made on the ship up to 3-30 P.M. of the 14th was it possible to say that the storm was moving in a direction with an easterly element.

I believe the above remarks show clearly that, so far from Sir J. Eliot's statement being correct, that the inner storm area can be avoided, it is in the present state of our knowledge of meteorology a matter of good fortune rather than of management that ships are not more frequently involved in severe storms. Luckily severe storms are rare, their danger extends over a small area, and the rapid rate at which they move further diminishes the risk of many vessels becoming involved.

There is another matter on which this question of recurving bears with no small importance, that is, the storm warning of ports. My practice has been, when a storm such as the cyclone of the 14th November 1903, or the Chittagong cyclone of October 1897, enters the north of the Bay, to issue warnings to all the ports in the north of the Bay. It must be obvious that this storm of the 14th November last, might have struck the land at the mouth of the Hooghly, or Chittagong or Akyab according to the amount of recurving. I had the same difficulty with the cyclone of November 26th 1901, which came on the mouth of the Hooghly and which residents of Calcutta will remember passed a little to the west of this city.

The result of this system of warning is that the port affected is generally warned beforehand, but along with that port there are perhaps six others where precautions have been taken and weather has not been to any great extent affected. A further result is damaging suspicion as regards what Sir J. Eliot calls the "intelligence of the person" who issued the warnings. The difficulty arises from the recurving of all dangerous storms; in fact it may almost be said that recurving is rarely present at sea where there is not danger. It appears then to be associated with exceptionally strong winds, just as inland it



is associated with exceptional distribution of rainfall, frequently with heavy flooding.

The only remedy is investigation of the upper strata of the atmosphere, because ground level observation fail to display the causes, and therefore fail to indicate its occurrence beforehand.

It may be said that with the introduction of wireless telegraphy earlier and better information will be available. The experience of these two ships in the cyclone of November 14th shows how difficult it is for ships at sea to find out what is happening within a few miles of them, and it may be inferred that, even with an efficient system of wireless telegraphy, guaranteed to continue working in all kinds of weather, and more especially to be independent of thunderstorms, it is doubtful whether much information will be procurable from the shipping in the Bay at the time of the storm.

The Andaman connection might have given some information on the 13th which would have shown that a storm was approaching the north of the Bay and moving towards Gopalpur, but on the point of greatest importance, *viz.*, whether the storm would strike the mouth of the Hooghly or Chittagong or Akyab, information from the Andamans would have been of no assistance.

When we come to consider that wireless telegraphy fails when thunderstorms are occurring, and that thunderstorms are constantly occurring in the early stages of cyclonic weather, the probability of assistance in forecasting weather by that means becomes practically nil. Wherever wireless telegraphy has been tried so far, its working has been temporarily abandoned during thunderstorms; and this is so great a drawback in storm warning work that the United States Weather Bureau, after a lengthy trial of wireless telegraphy, have put it aside for the present, and are continuing the laying of submarine cables over the short distances between their mainland and neighbouring islands. If wireless telegraphy fails for that reason as an aid in storm warning in the temperate region, it is much more likely to fail in the tropics where lightning is an almost constant accompaniment of even a slight atmospheric disturbance. Those who doubt the interference of lightning with wireless telegraphic work may refer to the latest Administration Report of the Telegraph Department in India.

It is practically certain that no improvement in storm warning will follow the introduction of wireless telegraphy. A cable to the Andamans would, undoubtedly, give valuable information, but only ground level information which is not sufficient to settle the important question of recurving. There remains the investigation of the upper strata suggested by Mr. H. F. Blanford more than twenty years ago

and still awaiting introduction in India. For what is being done in this direction in other countries the reader may be referred to pages 7 to 14 of the Report for 1903 of the Chief of the United States Weather Bureau, and more especially to the subsequent pages in which some idea is given of the lavish expenditure at present being incurred in establishing a central observatory for purposes of training and research. To quote the report :—

“The Weather Bureau is so far convinced of the importance of finding out the laws of this cosmical physics, by which alone the problem can be conclusively solved, that it has been thought proper to found a research observatory at Mount Weather, on the crest of the Blue Ridge mountains, and equip it suitably for these investigations.”

“Generally, the idea is to bring together for study under one direction the most valuable and practical observations having a direct bearing on the higher meteorology, which is now engaging the attention of many able physicists and astronomers.”

“Plans are being prepared for a plant adapted to generate large quantities of hydrogen, for balloon ascensions, including a shop for the construction of balloons and kites. The ascensions will be limited to about 4 miles in height, our immediate purpose being to measure the temperatures and thermal gradients, which will enable us to construct daily isothermal charts on the two upper planes already described, (3,500 and 10,000 feet high) so as to provide isotherms as well as isobars on the high levels. It is proposed to make a complete series of ascensions—first at Mount Weather, and afterwards in different portions of the United States, in order to observe the temperature conditions in all classes of cyclones and anticyclones. We may attempt some high ascensions, up to 10 or 12 miles from the ground, when our experience and other conditions warrant ; but since storm movements are practically limited to the strata within 4 miles of the ground, the first group of ascensions will be to moderate elevations.”

If the most experienced meteorologists of the time consider such operations necessary to further meteorological research in the United States, it may be safely anticipated that in India where the upper atmosphere, more especially in Bengal, passes through a cycle of change of greater variety and interest, the advantage of similar investigation to both storm and flood warning would be enormous.

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